DEVELOPMENT AND VALIDATION OF CRACK GROWTH DATABASES FOR USE IN DAMAGE TOLERANCE APPROACH

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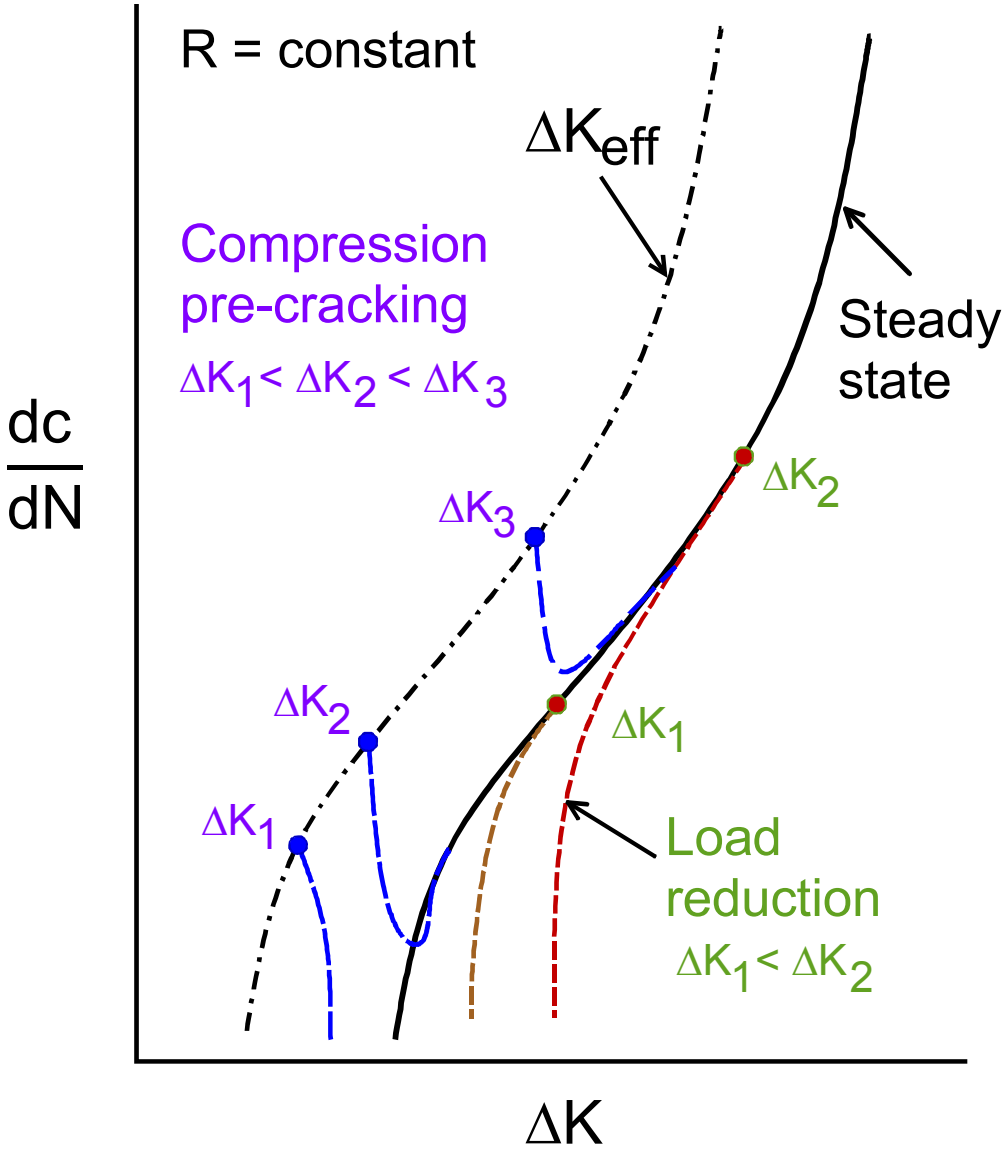
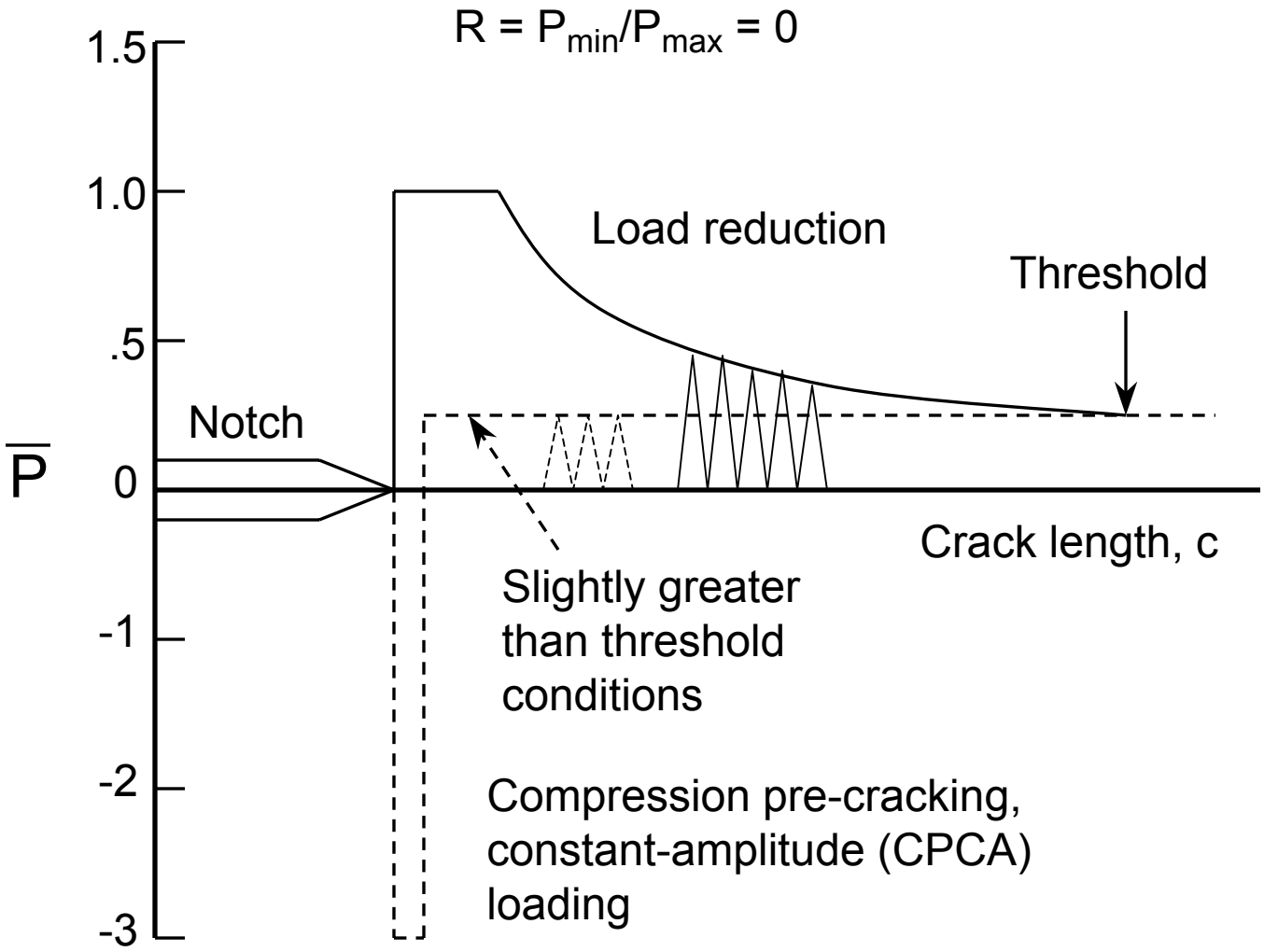
Rotorcraft Damage Tolerance, Health and Usage Monitoring Systems Research Review Meeting
NASA Ames Research Center
7 December 2004

**USDOT/FAA 01-C-AW-MSU Amd 010*
Dr. Dy Le, Monitor, FAA William J. Hughes Technical Center

WHAT IS THE CONCERN?



WHICH LOADING HAS LESS HISTORY EFFECTS ON CRACK GROWTH?



OUTLINE OF PRESENTATION

- **Review test and analysis program for FAA Grant and NASA Langley testing on rotorcraft materials**
- **Review some of the analyses on crack-growth-rate data generated at NASA Langley for:**

  7050-T7451
  7075-T7351 (LT)
  D6AC Steel
  4340 Steel

- **Review CPCA test results on 7075-T7351 (TL) tested at MSU under ONR Grant**
- **Concluding Remarks**

ROTORCRAFT COMPANIES, CONTACTS AND PROPOSED MATERIALS

- **Bell Helicopter – *Dr. Sohan Singh* – (TBD)**
- **Boeing – *Dr. Ashok Sane* – 4340 Steel**
- **Sikorsky – *Dr. John Wang* – Ti-6Al-4V (β-STOA)**

TEST MATRIX FOR ROTORCRAFT MATERIALS

Type of Test	R = 0.1	R = 0.4	R = 0.7	R = 0.9	Total
Load Reduction	3	3	2	2	10
K_{max}	-	4	-	-	4
CPCA	4	4	4	4	16
Total	7	11	6	6	30

ROTORCRAFT MATERIALS TESTING

- **FAA Contract with NASA Langley – Conduct load-reduction, K_{max} tests, compression pre-cracking constant-amplitude (CPCA) threshold testing for:**

  7050-T7451
  9310 Steel
  Ti-6Al-4V (β-STOA)
  Mg AZ91E

- **FAA Grant with MSU - Analyze crack-growth-rate data generated at NASA LaRC to obtain ΔK_{eff}-rate curve and ΔK-rate curves for various stress ratios**

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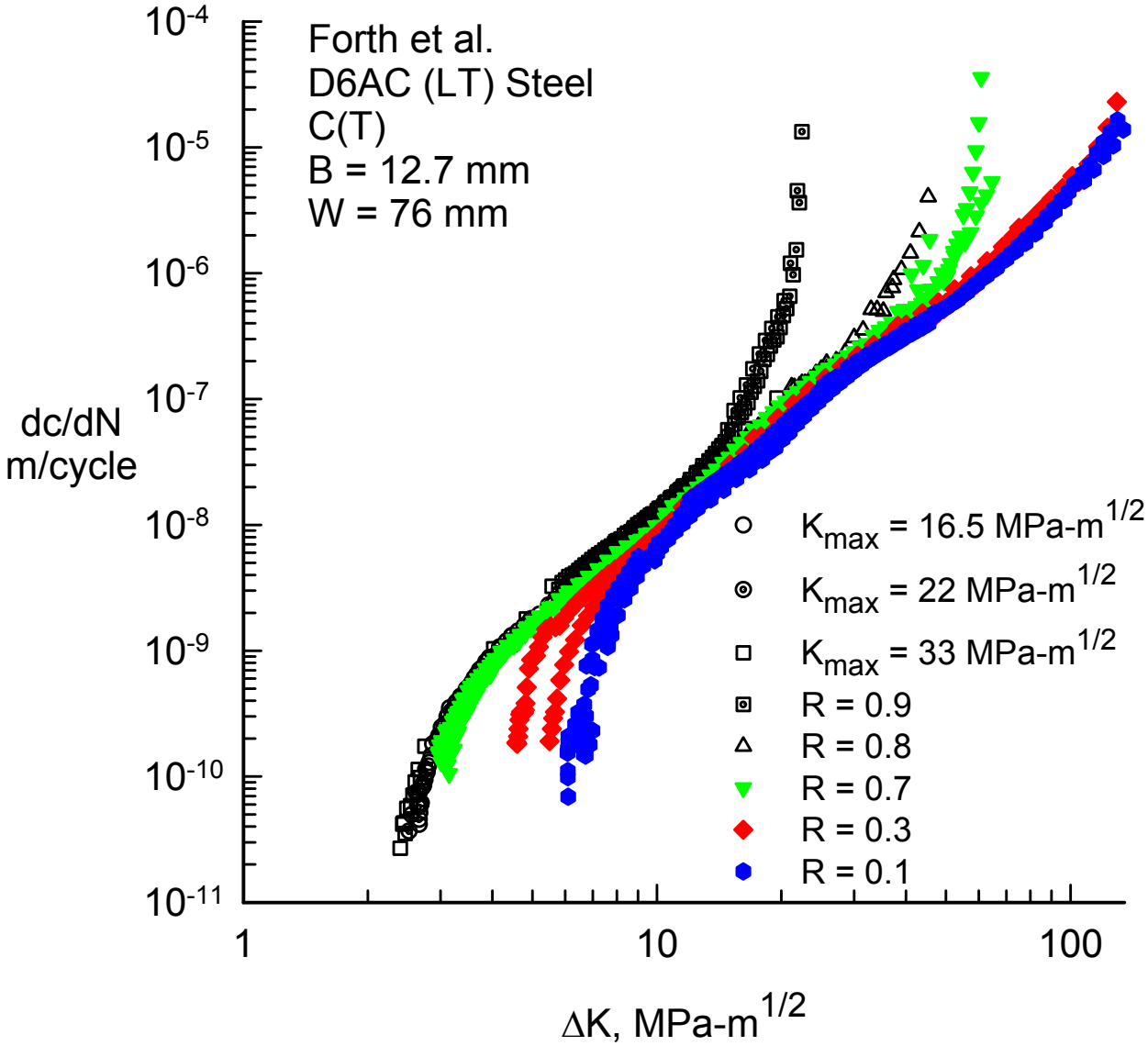
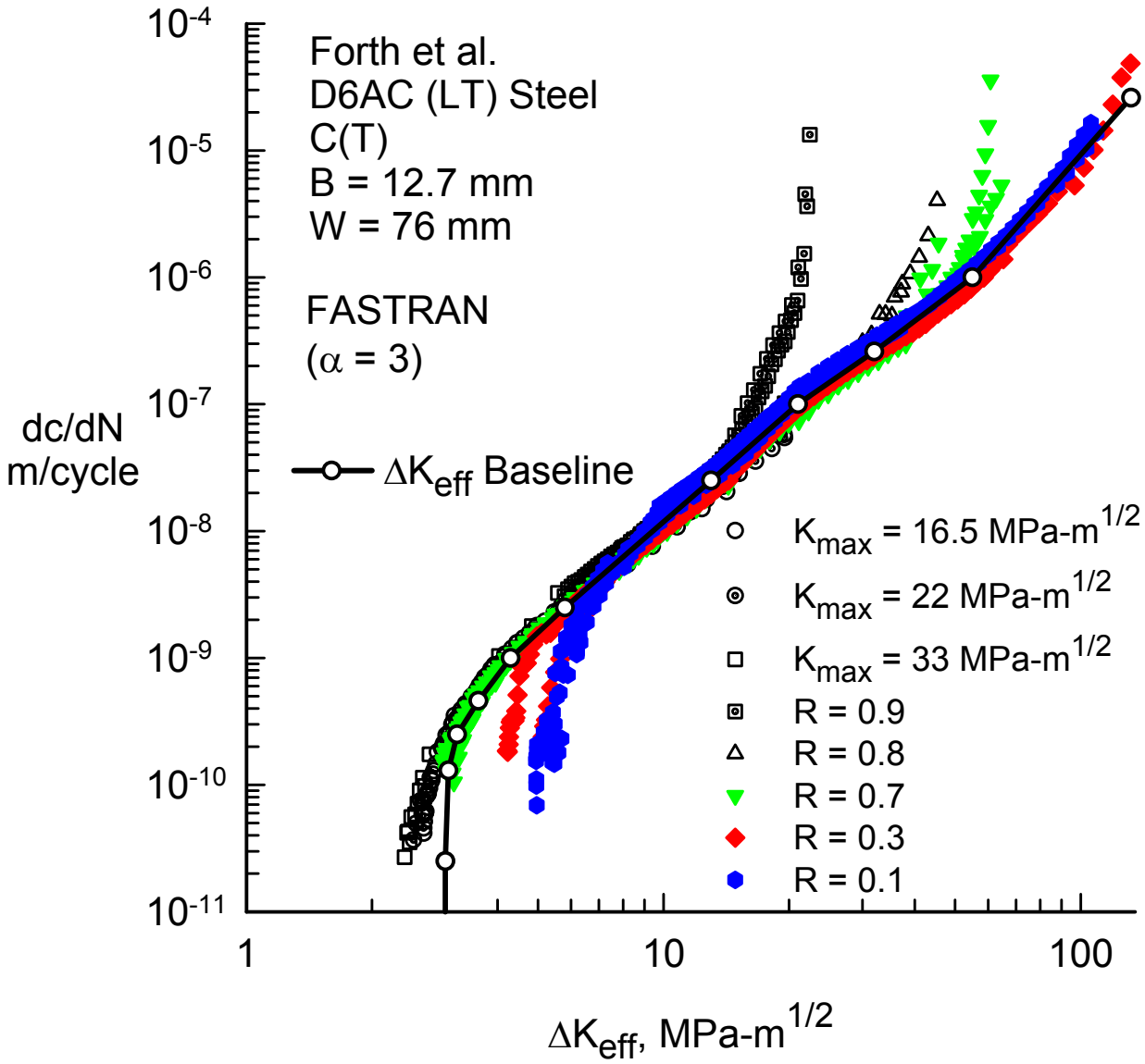
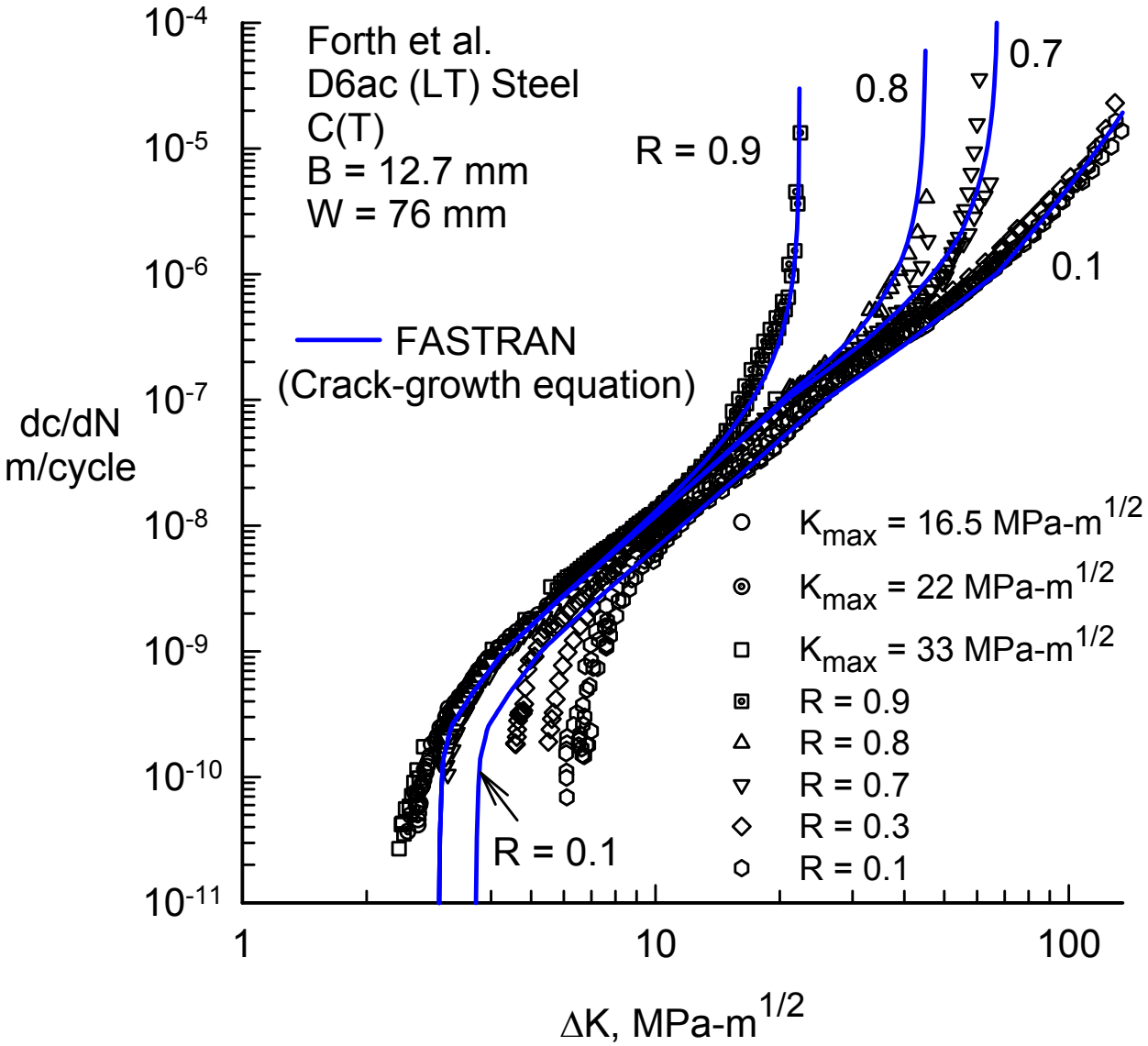
CONSTANT-AMPLITUDE LOADING DATA GENERATED ON D6AC STEEL WITH LOAD-REDUCTION PROCEDURE



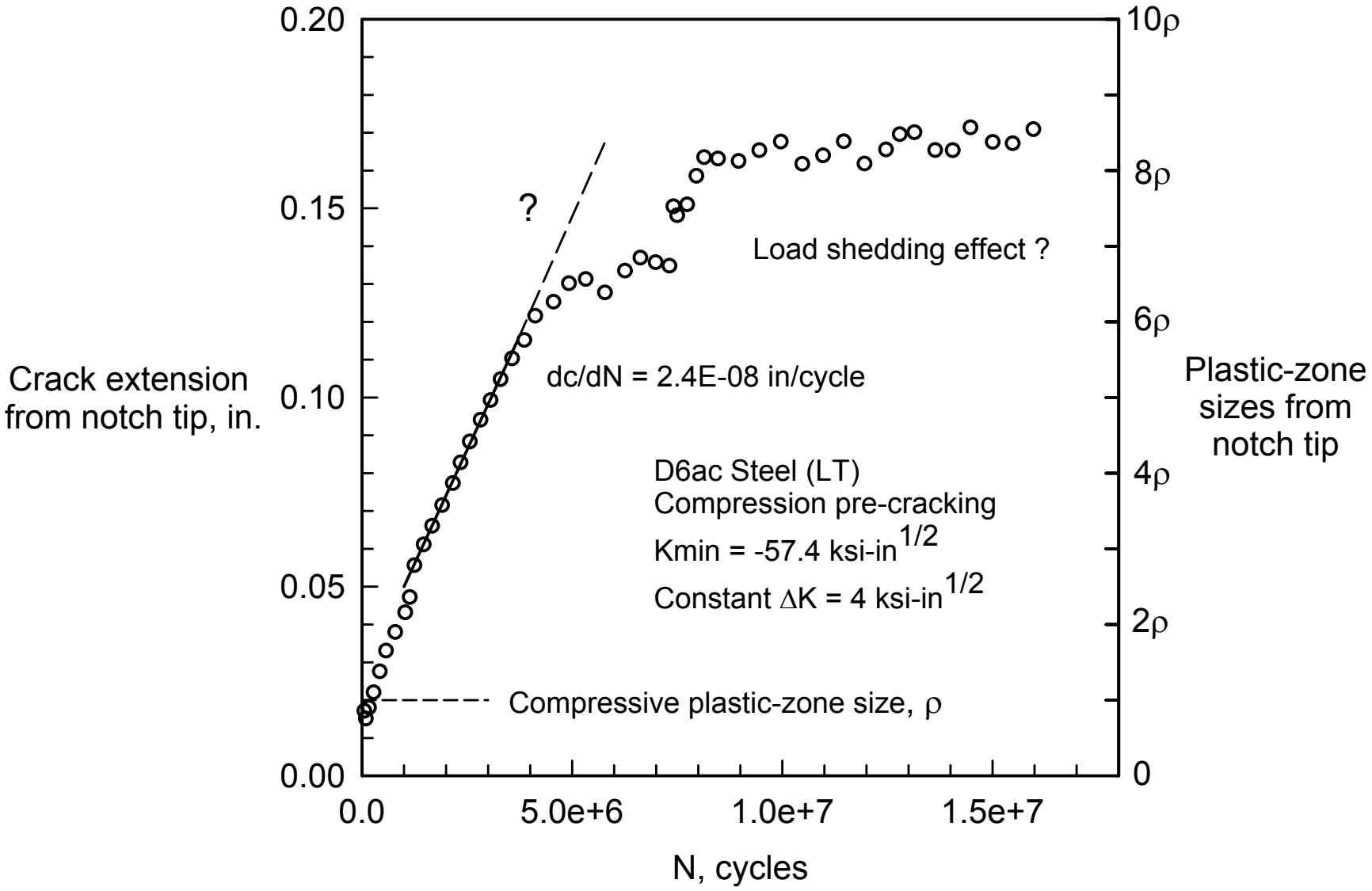
CORRELATION OF D6AC DATA USING CLOSURE MODEL



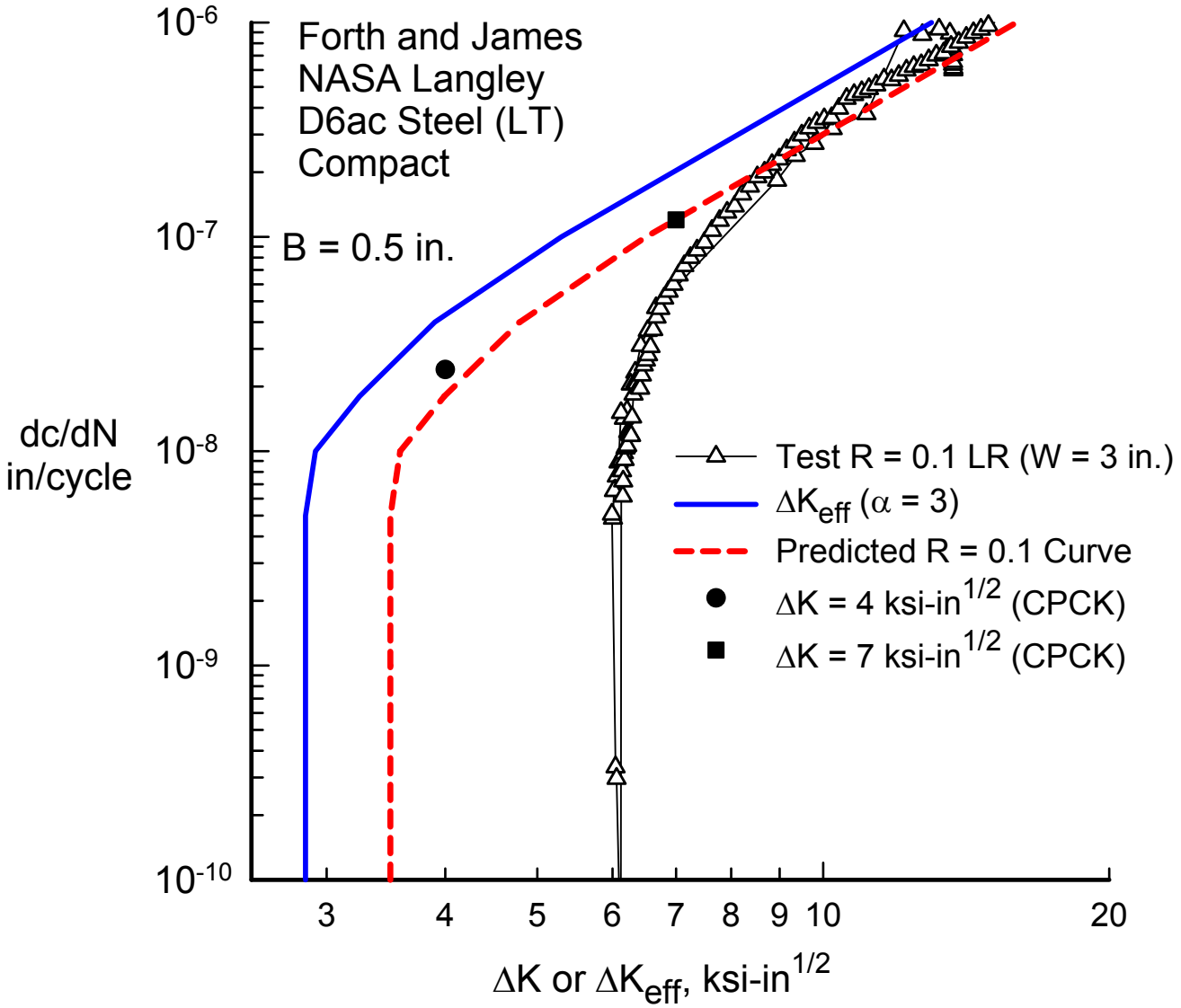
CRACK-GROWTH RATE CURVES FROM CLOSURE MODEL



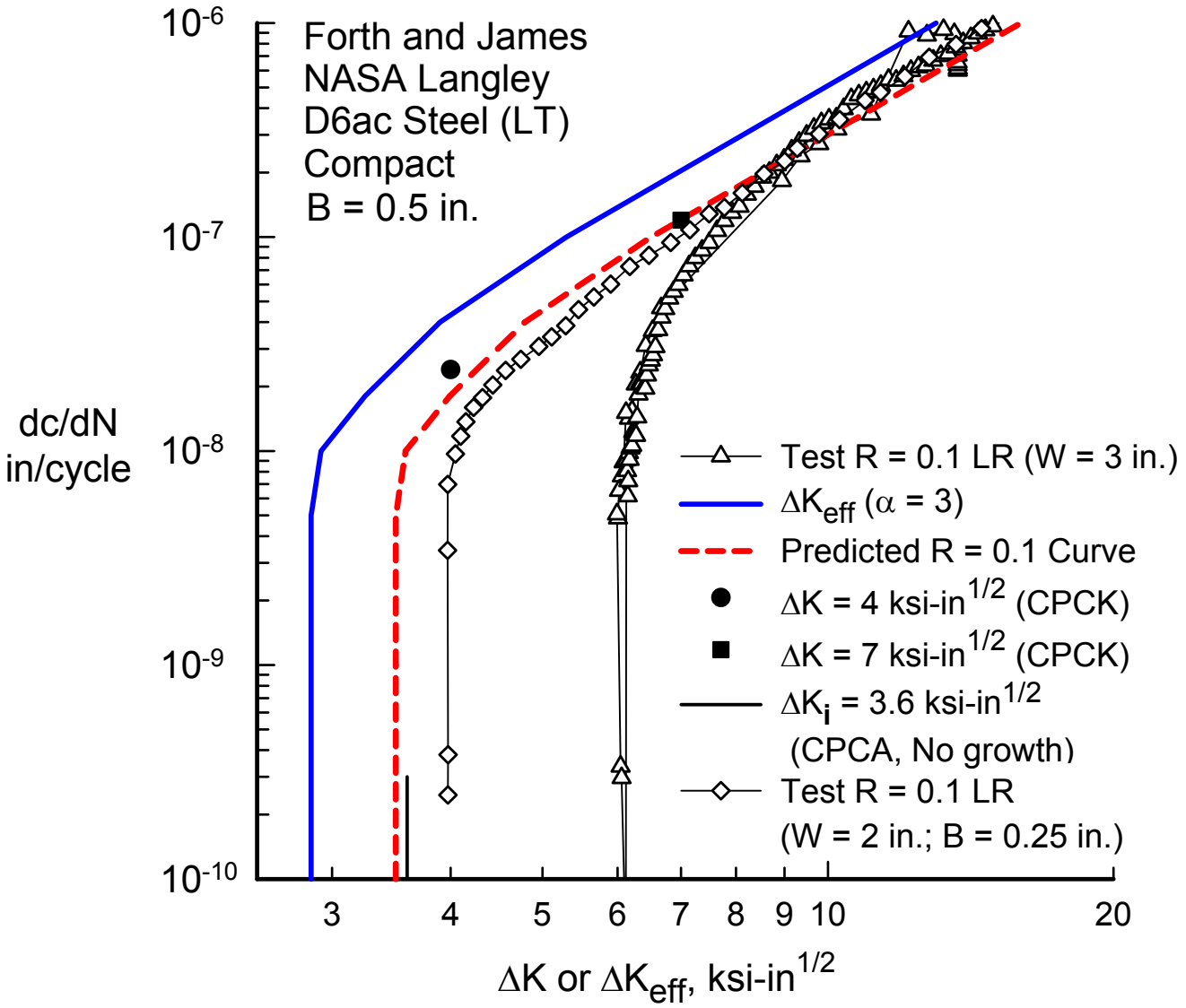
D6AC STEEL COMPACT SPECIMEN UNDER CPCK (4 ksi-in$^{1/2}$) LOADING



CPCK RESULTS ON THE D6AC STEEL



CPCA RESULTS ON THE D6AC STEEL



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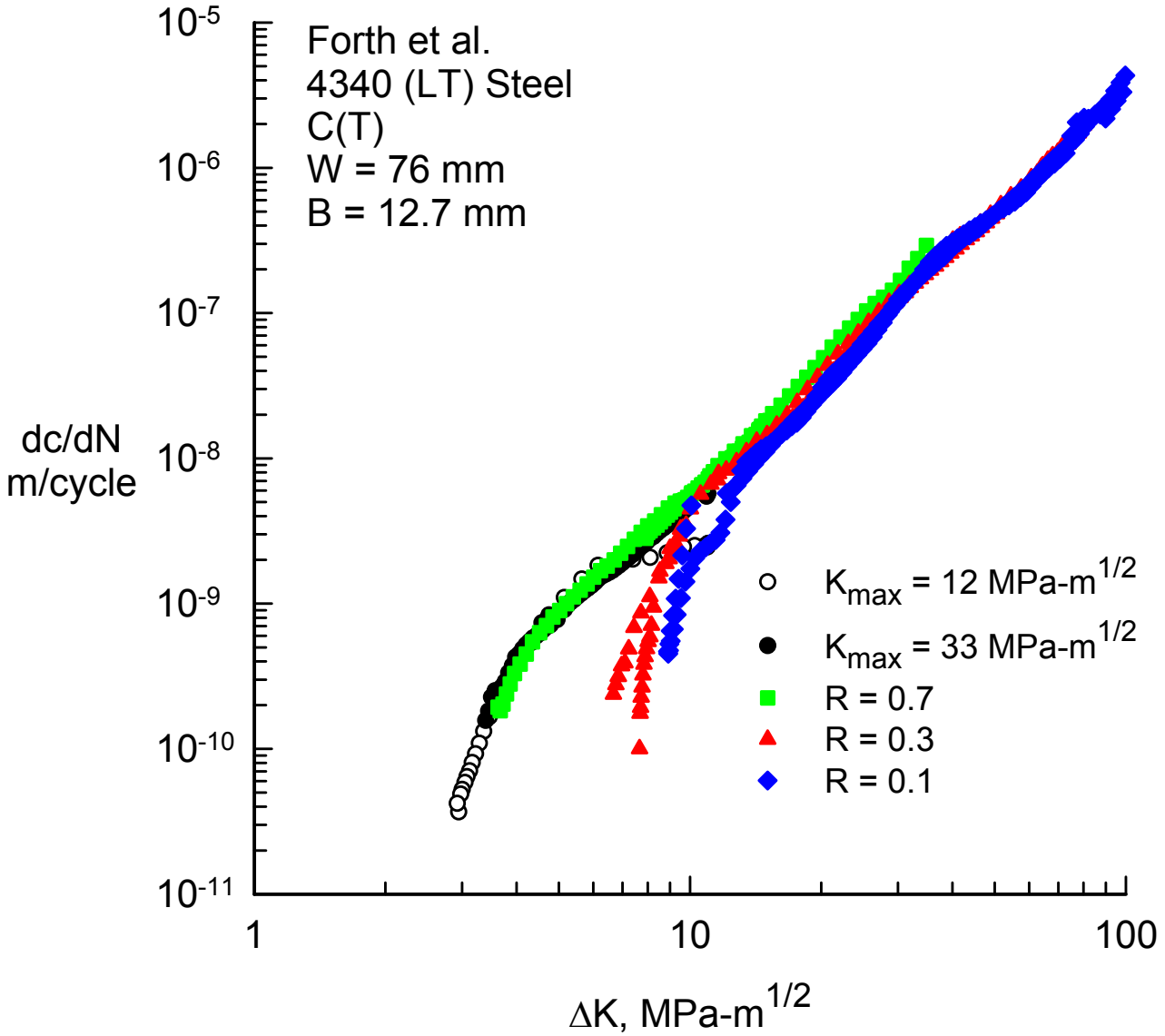
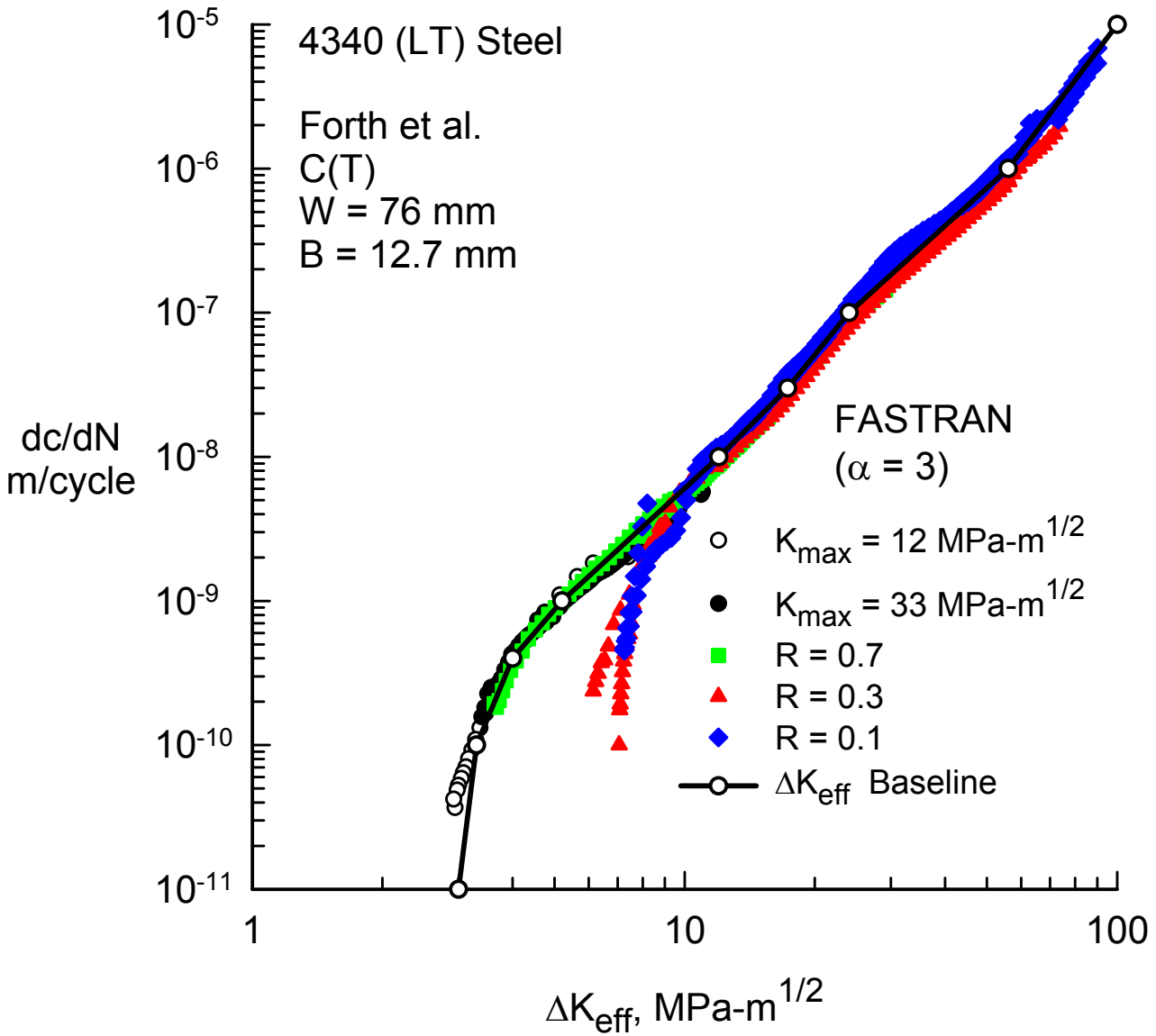
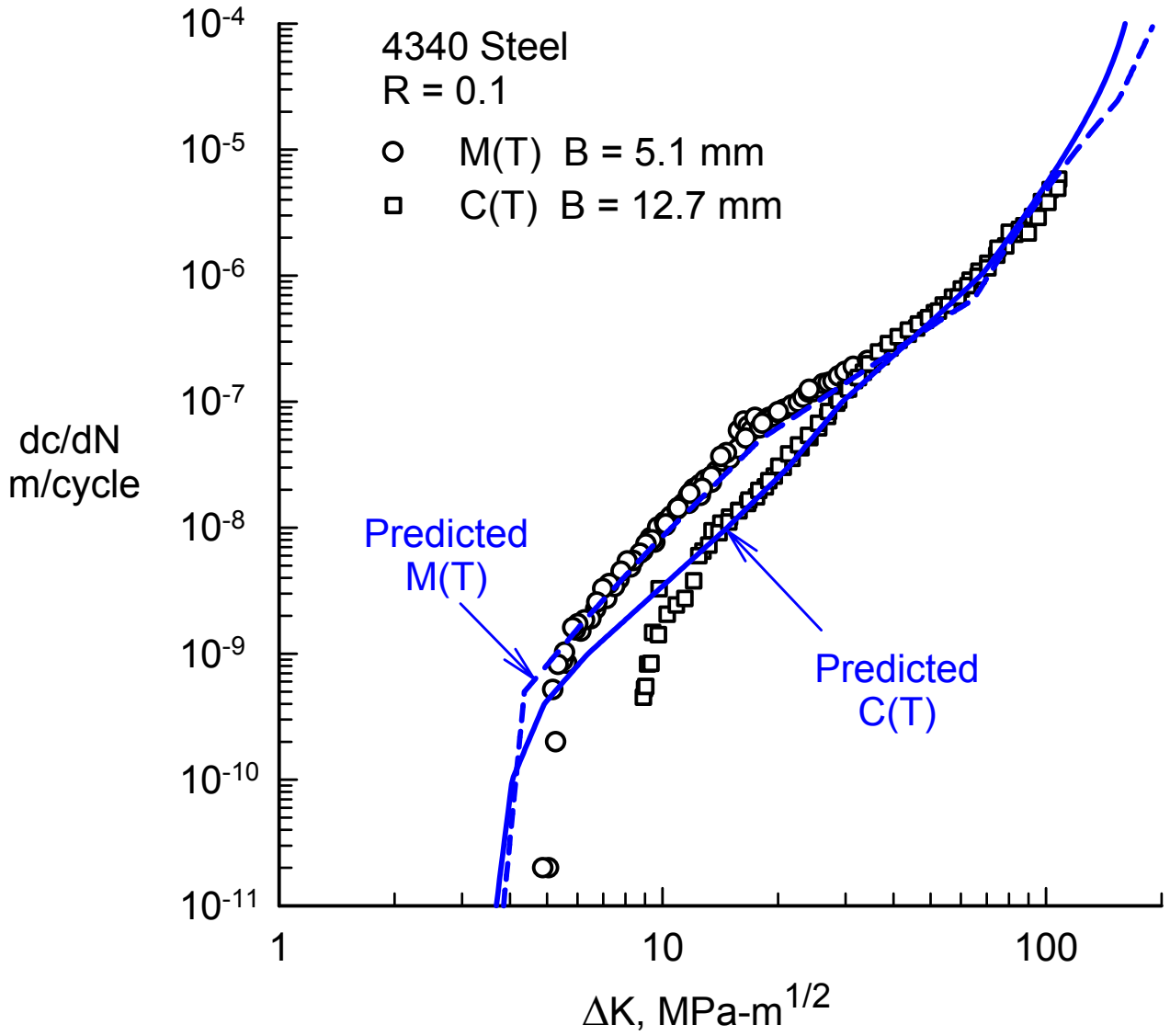
CONSTANT-AMPLITUDE LOADING DATA GENERATED ON 4340 STEEL WITH LOAD-REDUCTION PROCEDURE



CORRELATION OF 4340 DATA USING CLOSURE MODEL



MEASURED AND PREDICTED CRACK-GROWTH RATE CURVES FOR M(T) AND C(T) SPECIMENS



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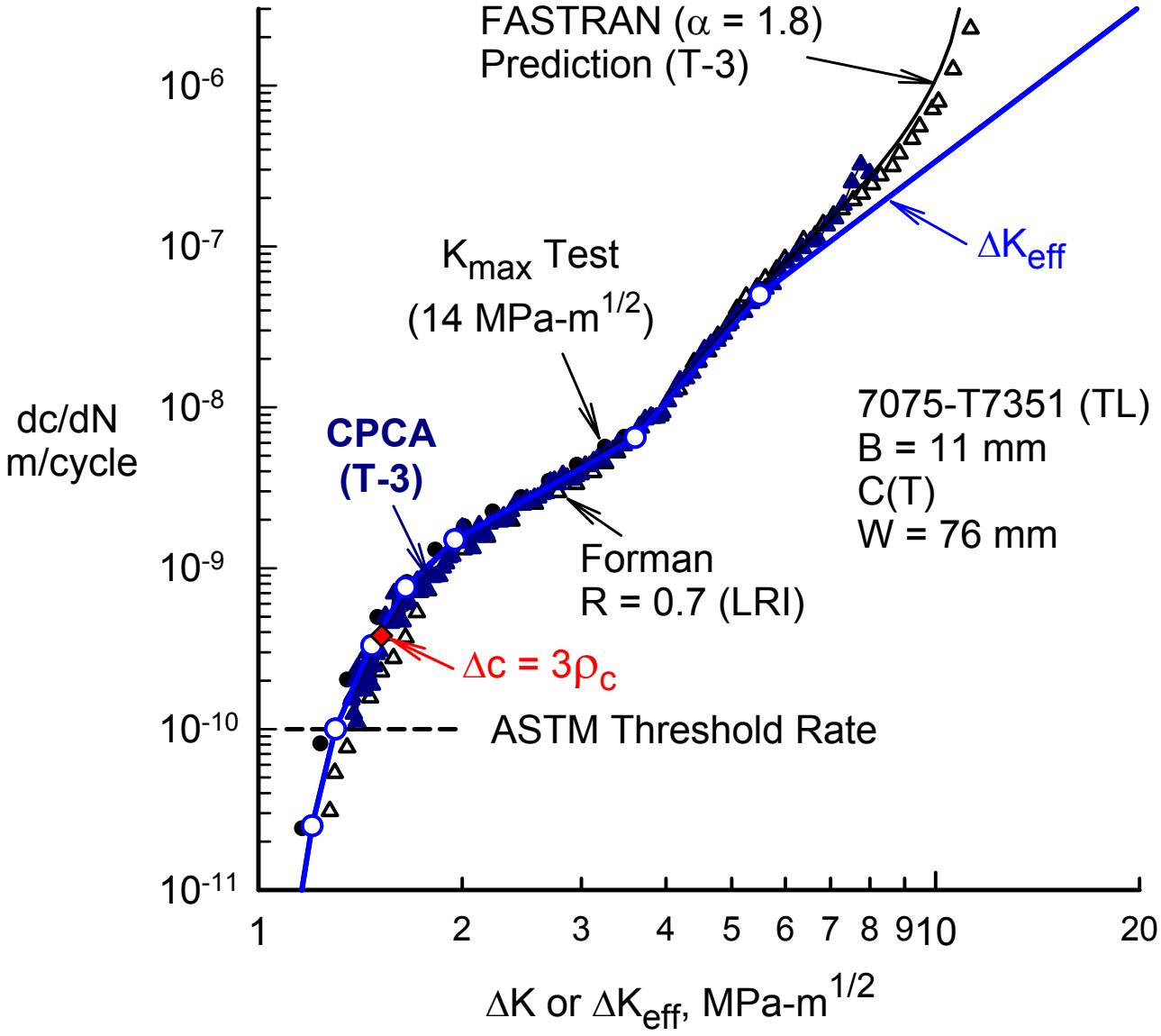
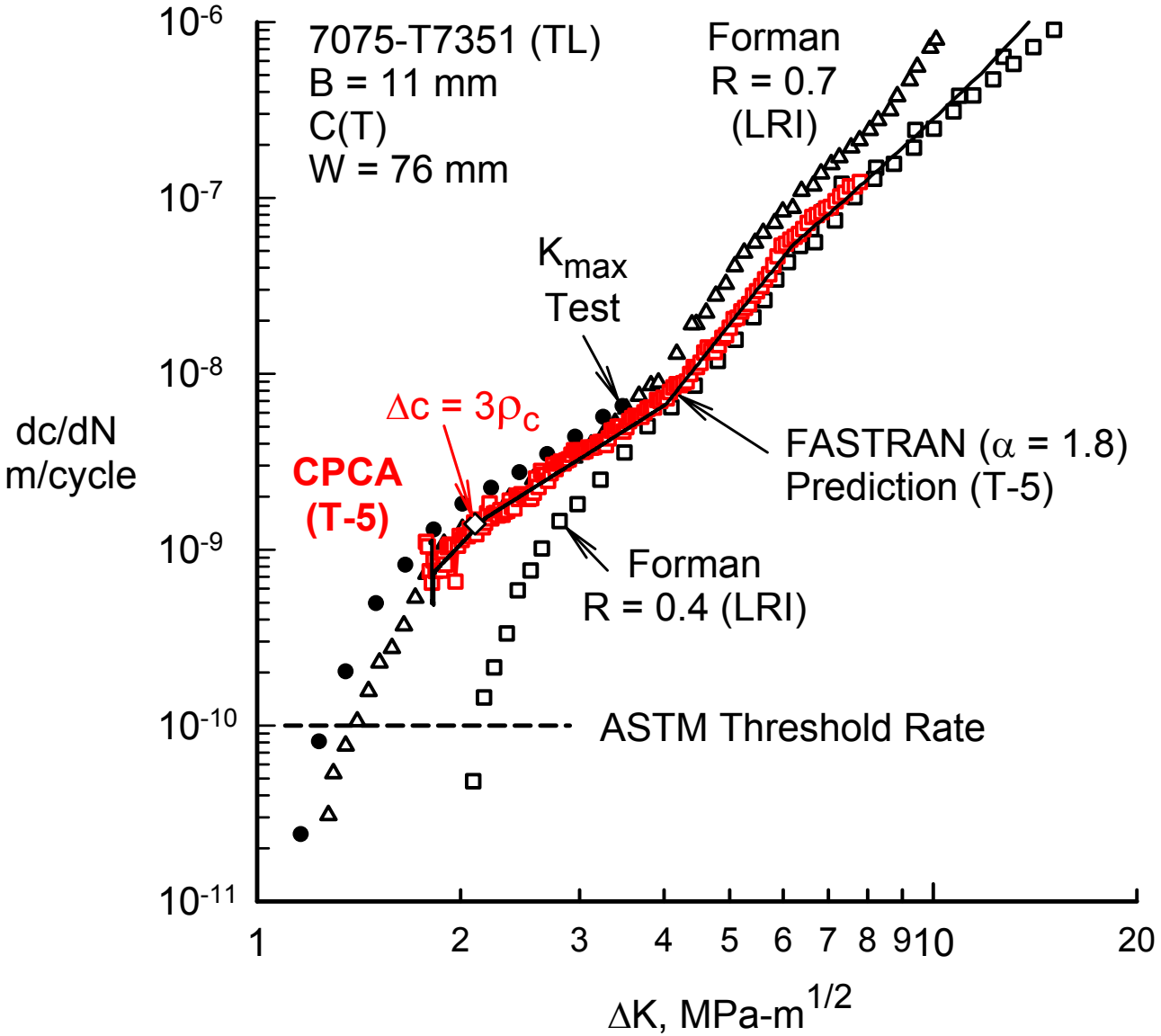
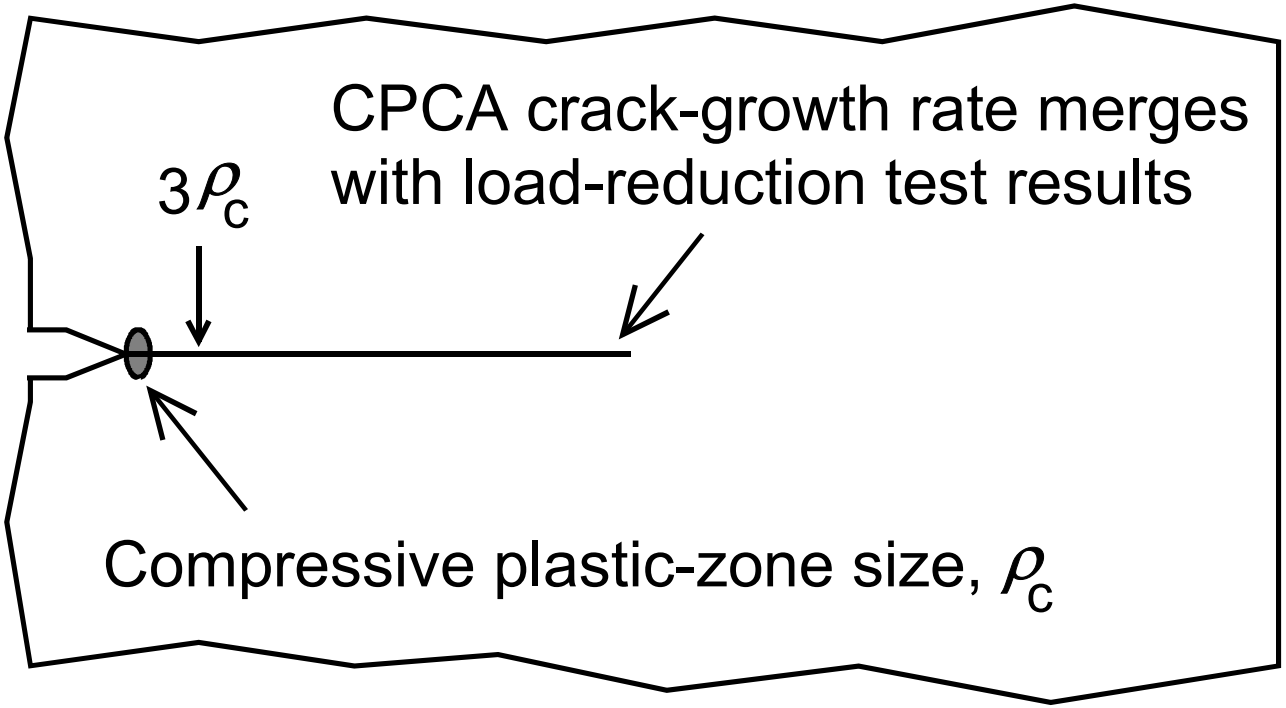
CPCA AND LOAD-REDUCTION THRESHOLD TESTING AT HIGH STRESS-RATIO CONDITIONS ON 7075-T7351 ALLOY



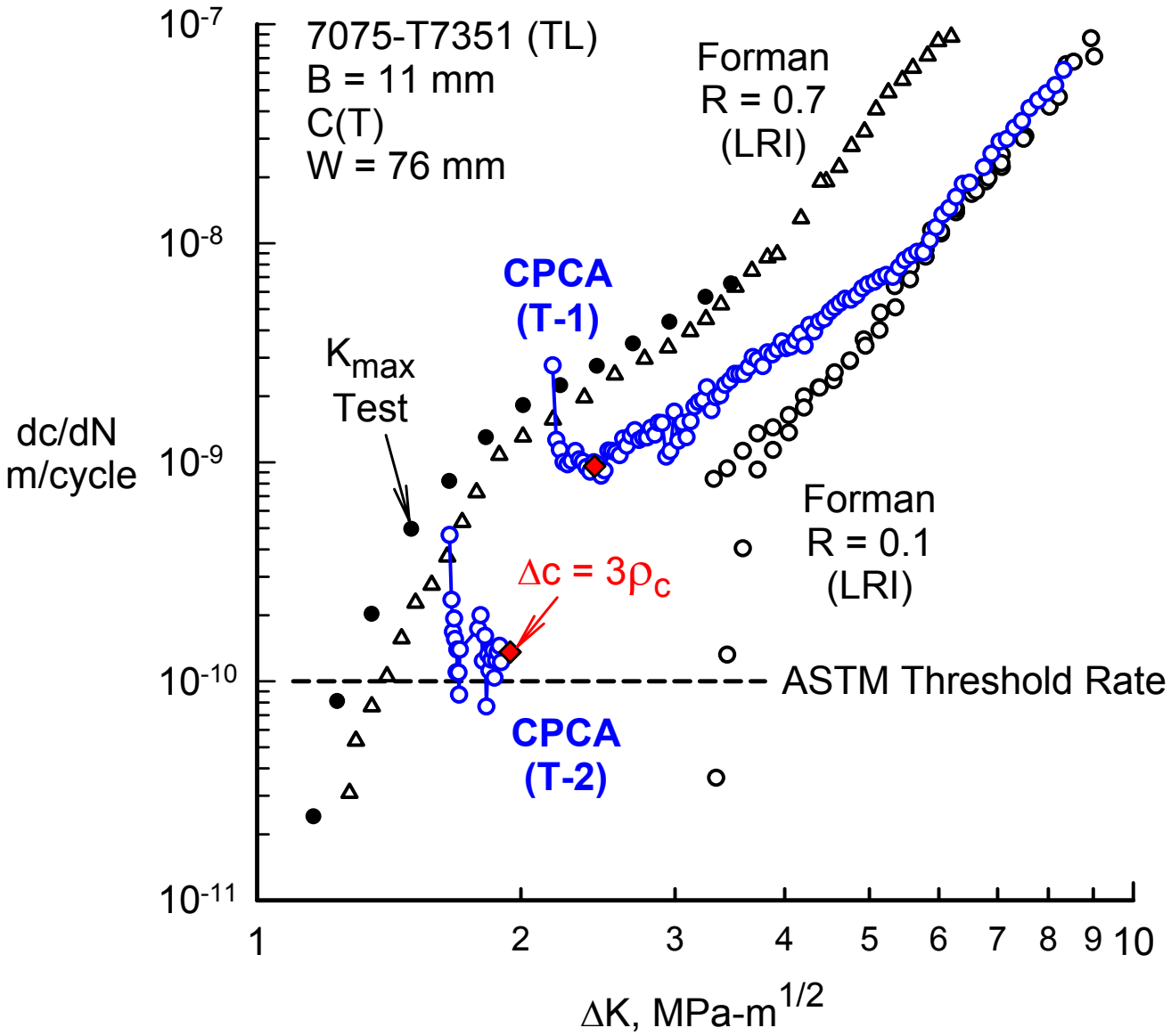
CPCA AND LOAD-REDUCTION THRESHOLD TESTING ON 7075-T7351 AT R = 0.4 CONDITIONS



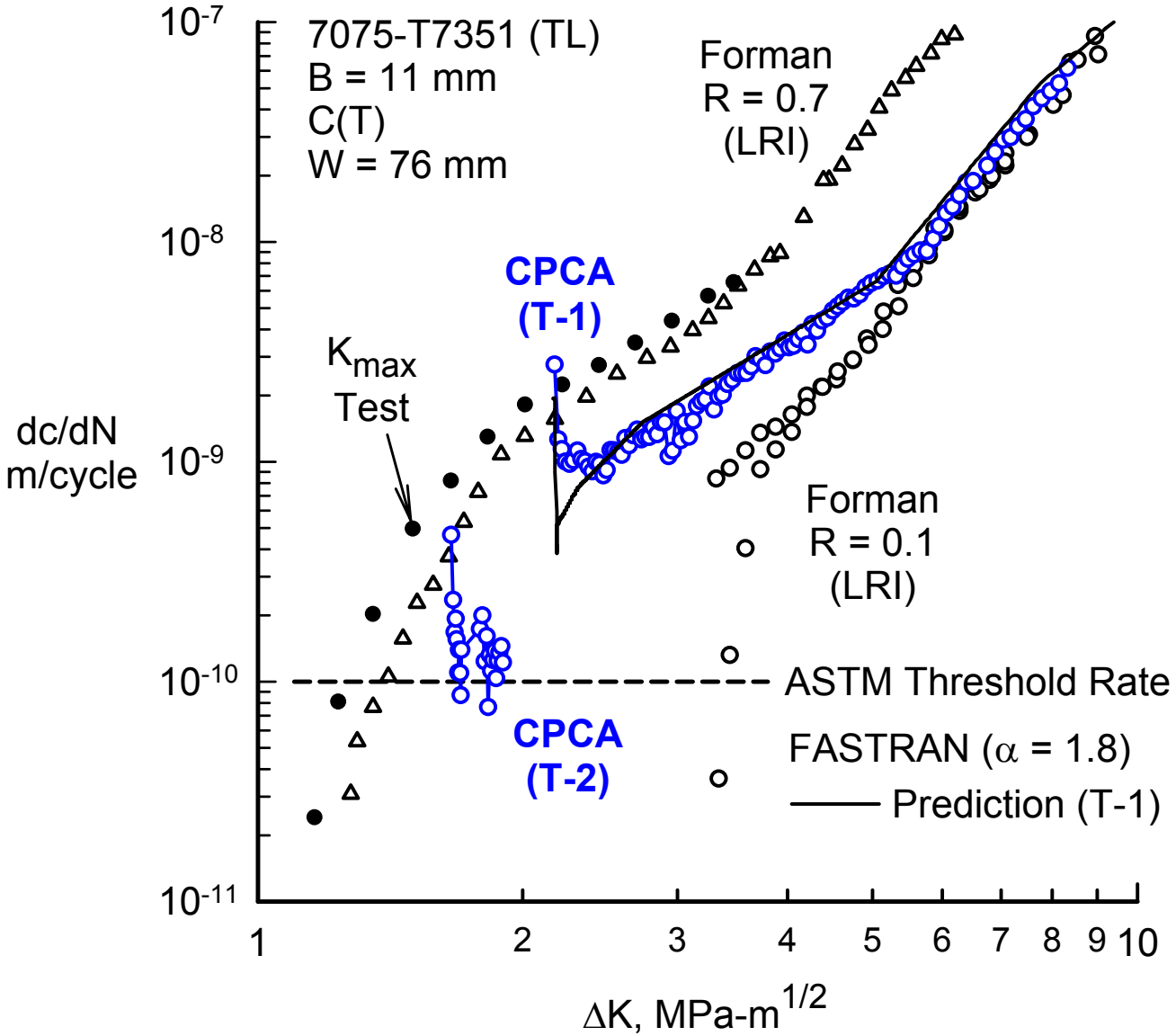
LIGAMENT OF COMPACT SPECIMEN



CPCA AND LOAD-REDUCTION THRESHOLD TESTING ON 7075-T7351 AT R = 0.1 CONDITIONS



FASTRAN PREDICTION OF CPCA TEST T-1



CONCLUDING REMARKS

- Load-reduction threshold tests can produce higher thresholds at low or high stress ratio (R) conditions, if the initial stress-intensity factor is much higher than the threshold ΔK_{th} values.
- Load-reduction threshold tests can produce slower rates in the near-threshold regime at low or moderate stress ratios, than steady-state constant-amplitude conditions.
- Threshold and near-threshold data generated on compact C(T) and middle-crack tension M(T) specimens may be significantly different in the near-threshold regime.
- Compression pre-cracking constant-amplitude loading (CPCA) tests provide an alternative method to generating "steady-state" fatigue-crack-growth rates in the near threshold regime, after some crack extension ($\Delta c > 3\ \rho_c$).